Cloud and aerosol measurements from GLAS: Overview and initial results

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[1] Global space borne lidar profiling of atmospheric clouds and aerosol began in 2003 following the launch of the Geoscience Laser Altimeter System (GLAS) on the Ice, Cloud and land Elevation Satellite. GLAS obtains nadir profiles through the atmosphere in two wavelength channels, day and night, at a fundamental resolution of 76.8 m vertical and 172 m along track. The 532 nm channel uses photon-counting detectors and resolves profiles of observed backscatter cross sections to 10^{-7} 1/m-sr. The 1064 nm channel employs analog detection adequate to 10^{-6} 1/m-sr and with greater dynamic range. By 2005 approximately seven months of global data are available. Processing algorithms produce data products for the corrected lidar signal, cloud and aerosol layer boundaries and optical thickness and extinction and backscatter cross sections. Operational sensitivity is shown by the frequency distribution for cloud optical thickness peaking at approximately 0.02. **Citation:** Spinhirne, J. D., S. P. Palm, W. D. Hart, D. L. Hlavka, and E. J. Welton (2005), Cloud and aerosol measurements from GLAS: Overview and initial results, *Geophys. Res. Lett.*, *32*, L22S03, doi:10.1029/2005GL023507.

1. Introduction

[2] Since the advent of satellite remote-sensing, passive imaging radiometers of multiple types have provided observations of global cloud and aerosol layer distributions. Yet there are issues of increasing importance where passive sensing alone is not adequate. Both cloud feedback and the influence of aerosol are considered major uncertainties for predictions of global warming. Global observations should be sufficient to provide adequate information for climate models, but also of sufficient sensitivity to monitor critical component variability in response to climate change. Passive instruments do not provide direct and accurate observations of the height distribution of aerosol along with accurate extinction and absorption information. Similarly for cloud cover, errors in height and coverage from passive retrieval are typically large in comparison to the impact on infrared forcing from increasing greenhouse gasses. Active laser remote sensing of the atmosphere has the major advantage of a direct and unambiguous detection and height measurement of all scattering layers, and thus space borne lidar observations will be an important addition to existing satellite observations.

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[3] The first polar-orbiting satellite lidar instrument, the Geoscience Laser Altimeter System (GLAS), was launched on board the Ice, Cloud and land Elevation Satellite in January 2003 and has provided extensive global data on cloud and aerosol distributions. As part of the NASA Earth Observing System (EOS) project, the GLAS instrument is intended as a laser sensor fulfilling complementary requirements for several earth science disciplines [*Zwally et al.*, 2002; *Spinhirne and Palm*, 1996]. The overall approach takes advantage of the good technical compatibility of cloud and aerosol profiling with laser altimeter measurements for ice sheet and land requirements. In addition, a mission that combines surface altimetry and high quality atmospheric measurements best overcomes inter related remote sensing problems such as the effect of cloud scattering on precision altimetry [*Duda et al.*, 2001].

[4] In this paper we present an initial description of the GLAS atmospheric observations. Specific examples of the application of GLAS data to a range of issues are given in this special section [*Hlavka et al.*, 2005; *Palm et al.*, 2005a, 2005b; *Spinhirne et al.*, 2005; *Hart et al.*, 2005]. The stated measurement requirement for GLAS was to profile all radiative significant cloud and aerosol layers. The measurement result from the fully operational instrument meets the requirement. An important part of the development of the GLAS project was the construction and testing of automated data processing algorithms capable of operational production of higher-level research parameters. We describe the GLAS cloud and aerosol data products available to the science community, starting September 2004.

2. GLAS Observation Requirements and Examples

[5] The lidar measurement requirements for clouds and aerosol from space were based on a long experience with airborne and ground based observations. The stated requirement to profile all significant cloud and aerosol translates to detection at appropriate spatial resolution of layers of optical depth down to 0.01. The requirement then further translates to the observation of backscattering cross sections to below 10^{-7} 1/m-sr. Airborne observations indicate that there is a "background" aerosol mode into the troposphere with cross sections at visible wavelengths on the order of 10^{-9}–10^{-8} 1/m-sr [*Menzies et al.*, 2002]. Thus some aerosol concentrations exist below the stated measurement requirement, but these aerosol are considered below the definition of radiative significant.

[6] The GLAS instrument is a dual-frequency, nadir-viewing laser radar system (J. Abshire et al., Geoscience Laser Altimeter System (GLAS) on the ICESat mission: